Tips

on

Spring Service

and

Inspection

SPRING RESEARCH INSTITUTE

SRI

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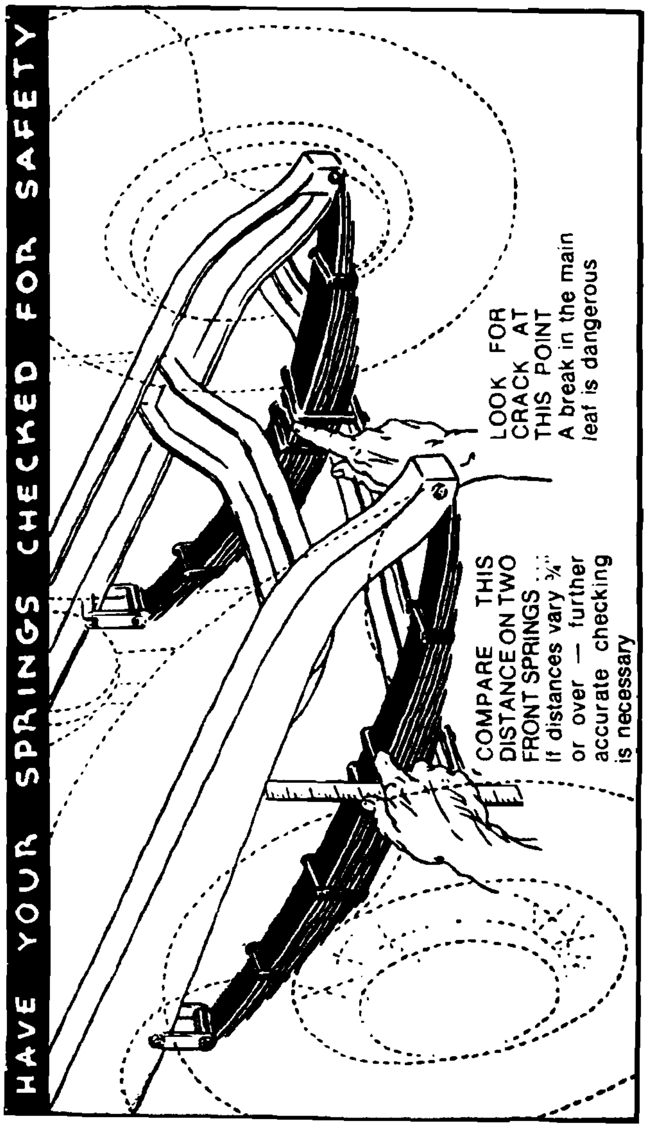
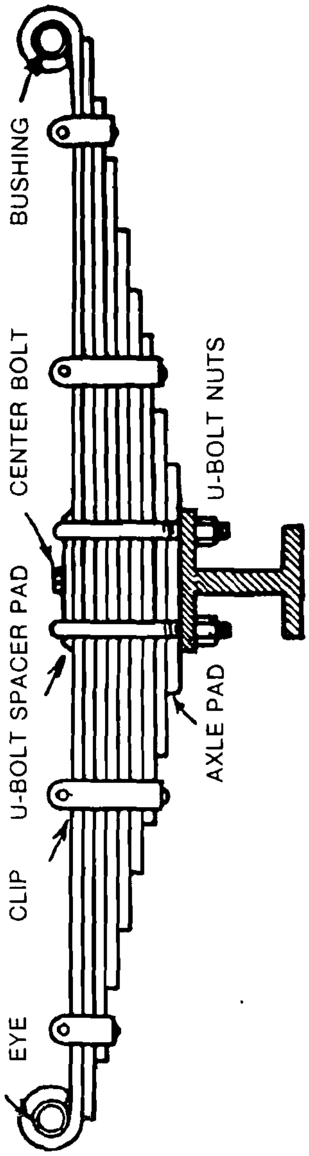


The leaf spring industry realizes that everything that benefits the users of vehicles having leaf springs, benefits in the long run the spring industry. For that reason, we have compiled the results of the experiences of prominent fleet operators and the opinions of spring engineers, in the belief that these will be helpful to those who inspect or have to do with the preventive maintenance and servicing of springs.



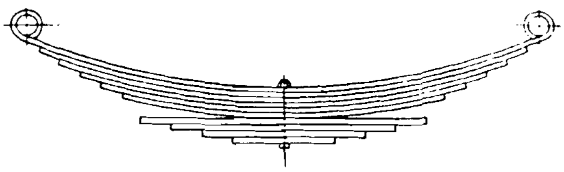
The motoring public has learned that proper maintenance on their vehicles is essential to obtain longer life and economical service in this age of rising equipment and fuel costs. In most normal maintenance checks the spring is sorrly over looked, but a minimum of attention to the springs would yield: (a) easier riding, (b) longer and more reliable spring service, (c) better stearing alignments.

When D'Artagnan and other warriors made punctures in each other with sharp rapiers, the swordsmen liked to test the integrity of their rapiers by bending them almost double—to make sure the rapiers would not break in actual combat.

It is customary practice, of some leaf spring manufacturers, to test every assembled spring in a "bulldozer." This bends the spring farther than it could ever be bent in actual service—before the axle makes metal-to-metal contact with the frame. While this does test the spring, and would reveal any flaws existing in the steel, the real purpose is something else . . .

By bending the spring farther in the bulldozer, than it would ever go in actual service; this stresses the metal, on the tension side of the leaves, a little beyond the yield point. This "pre-sets" the spring so that it will not settle or sag in actual use, and steering alignments will be better maintained.

It is obviously impractical to "pre-set" coil springs in this manner, because the adjacent coils of a helical spring make contact with each other—before the yield point is reached. This would seem to be the reason why coil spring front suspensions frequently settle or sag, during the first five or ten thousand miles of use, and then have to be replaced in order to restore normal steering alignments.



Semi-Elliptic Spring

Practically all leaf springs, as now used on cars, buses and trucks are of the semi-elliptic type. Because the semi-elliptic spring has the outstanding advantages of not only acting as a spring, to resiliently support the vehicle, but also serves the important functions of resiliently positioning the axles and of cushioning both driving torque and brake reaction, the simple semi-elliptic type has superceded many other kinds of springs, including cantilever, platform, full elliptic, etc. A semi-elliptic spring gives just as easy riding as the same amount of steel, built into a cantilever or full elliptic spring.

Full Taper

Athough not new to the market the full taper spring is now very popular for suspensions systems on light to heavy truck application. The major advantages to this type spring is its superior ride and overall reduction of vehicle weight, which nets greater revenue in load miles.

The full taper spring although superior in some aspects is not as forgiving as its counterpart the multi-leaf spring and should therefore be checked on regularly scheduled maintenance periods.

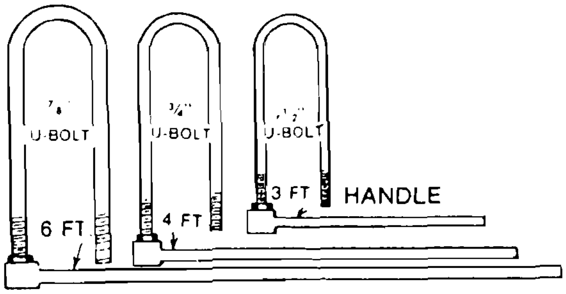
KEEP U-BOLT NUTS TIGHT!

"Tighten—and keep—those U-bolt nuts really tight" . . . is the keynote of good preventive maintenance of leaf springs.

Operators of large fleets of trucks and buses have found that center breakage of springs is greatly reduced by "retightening" U-bolt nuts—after the first day's run—when a spring has been repaired or replaced. There are a number of surfaces between the leaves which bed down a little during the first day's operation. But retightening takes up the resulting slack and the spring then remains tight for a longer period. Just as it is good practice to retighten cylinder head nuts, after the engine has been run a few hundred miles.

When installing U-bolts it is good practice to use torque wrenches to determine when U-bolt nuts had been adequately tightened. Since large torque wrenches are not yet standard equipment in all shops, fleet operators recommend the use of socket wrenches with sockets of length proportioned to bolt size, so that the mechanic can tell by the "feel" of the pull, or by the sound of the "creak," when the nut has been properly tightened. Fleet operators suggest for wrench handles. . . .

⅝ inch U-bolt nuts—handle 3 feet long.
¾ inch U-bolt nuts—handle 4 feet long.
⅞ inch and 1 inch U-bolts, handle 6 feet long.



Length of Wrench Handle Should be in Proportion to Bolt Size.

But torque wrenches and long handled wrenches, like micrometer calipers, are only as good as the mechanic who uses them. Instances have occurred where, due to insufficient length of threads or badly cut threads, torque wrenches have merely measured the "pull around" of the nut on the U-bolt, rather than the "pull together" of the spring and axle pad. Not only should threads be a correct fit, but both threads and contacting surface of nut should be lubricated with a mixture of graphite and 600-W oil or cup grease.

When in doubt as to whether the U-bolt nuts are really clamping parts together tightly, a sharp "rap" with a hammer will sound the answer. Just as railroad car wheel inspectors rap car wheels, before each long trip.

Further retightening, of new or repaired springs, is suggested at the end of the first 1,000 miles, after 3,000 miles and at each 5,000 miles thereafter.

"Army Ordinance," official U. S. Army publication, stated "bolts should be tightened, until they have stretched .003 inch per inch of length," and suggested that mechanics should practice—until they get the "feel" of a bolt that is properly tensioned. Practical mechanics tell us that they use the "creak" of a bolt, as the nut gives proper tension. Since the U-bolts of truck and trailer springs may be 10 to 20 inches long, then 20 times .003 inch is .060 which, with 16 threads per inch, would almost equal one full turn of the nut—after the nut had been seated solidly.

Although the afore mentioned methods of tightening are excellent rules of thumb you must consider the U-bolt material being used. Basic bolt grading are Grade 2 lowest, Grage 5 and Grade 8 highest or best.

The chart below shows the Maximum Suggested Torque—Fine Thread Series—On U-bolts

MAXIMUM SUGGESTED TORQUE FINE THREAD SERIES

Dia. Size and Threads/Inch	Grade	Max. Torque Ft.-Lbs.	Yield Strength P.S.I.
½ - 20	2	36	36,000
	5	92	92,000
	8	129	130,000
9/16 - 18	2	51	36,000
	5	131	92,000
	8	185	130,000
⅝ - 18	2	71	36,000
	5	181	92,000
	8	256	130,000
¾ - 16	2	124	36,000
	5	316	92,000
	8	446	130,000
⅞ - 14	2	197	36,000
	5	502	92,000
	8	710	130,000
1 - 12	2	293	36,000
	5	748	92,000
	8	1,057	130,000
1⅛ - 12	2	422	36,000
	5	949	81,000
	8	1,522	130,000

1¼ - 12	2	584	36,000
	5	1,313	81,000
	8	2,107	130,000
1⅜ - 12	2	782	36,000
	5	1,760	81,000
	8	2,825	130,000
1½ - 12	2	1,022	36,000
	5	2,299	81,000
	8	3,690	130,000

*** The C-1045 hot rolled steel cold bent meets the SAE standard of Grade 2 and is generally used in small Dia. U-bolts with light applications.**

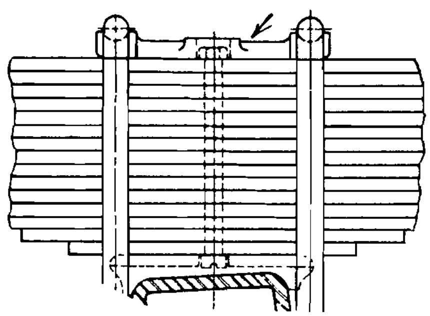
The SAE-1541 cold drawn, stress relieved material lends itself very well to those spring shops which have installed U-bolt bending equipment capable of forming threaded rod into the formed U-bolt in the **cold state.** The ultimate tensile strength, yield strength, elongation, reduction in area and hardness meet the specifications for the mechanical properties of Grade 7 and the material has been accepted by several Original Equipment manufacturers for truck U-bolt application. However, this material is somewhat questionable as to its impact resistance at low temperatures. To the best of our knowledge, impact resistance is a somewhat vague criterion as to how it affects the overall performance of this specific product and its intended use. We can find no reference to it as it relates to the various grades of fasteners.

The SAE-4140 material, fully heat treated after forming, fulfills all of the requirements of Grade 8 specifications and has superior impact resistance properties. For this reason we strongly suggest the use of SAE-4140, fully heat treated U-bolts for diameters of ⅝" and up.

We have emphasized U-bolt nut tightness because, when the middle of the spring is clamped solidly against the axle pad, as in a vise; then the middle of the spring cannot bend and, if it cannot bend, then it also cannot break at this point. Because the middle of the spring is the place of greatest hazard, it is necessary to clamp it securely to prevent breakage at this point.

It is possible for worn or improperly fitted axle pads to be a contributing cause of center spring breakage. Since many modern springs are flat, under normal full load, pads for such springs should also be flat, and only slightly rounded at the ends. Wear of spring pads can only be caused by movement of the spring on the pads. If the U-bolts have been holding the spring so tightly to the pad that no movement occurs, there can be little wear.

U-BOLT SPACER PAD



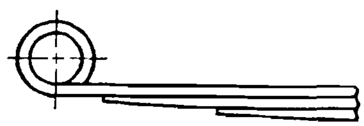
Don't Omit U-Bolt Spacer.

The U-bolt spacer plate is important for two reasons: (a) It maintains the U-bolts directly in the line of pull and parellel with each other. When this spacer plate is omitted, the long U-bolts may be pulled up at a slight angle and apparently tight. But when the vehicle flexes the spring, the U-bolts will gradually slide over to their true position and may loosen enough to cause middle spring breakage. (b) Because the spacer plates are shaped to fit the contour of the U-bolts, the U-bolts may be drawn up more solidly and more securely.

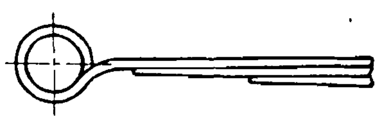
The center bolt assists in assembling, shipping and handling of the spring—before the spring is placed on the vehicle. After the spring is installed, the center bolt assist in preventing: (a) the lengthwise shifting of the leaves, (b) the fanning out of the leaves, (c) acts as an indicator to show the spring is correctly placed on axle. In all of these functions, it is only an assistant and, when a center bolt is bent or broken, the U-bolts should be suspected of having failed in their full duty of clamping the spring to the axle.

Spring eyes should be a free-running—but not a loose fit on the shackle bolts. Except when rubber bushings are used in the spring eyes, as in some applications, the spring shackle bolts should be regularly lubricated with chassis lubricant, to prevent freezing or binding of the spring eyes on the bolt. This might cause opening up of the eye, or "straight across" breakage of the main leaf near the eye.

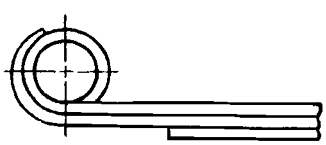
Typical Eyes of Springs.



UP-TURNED EYE

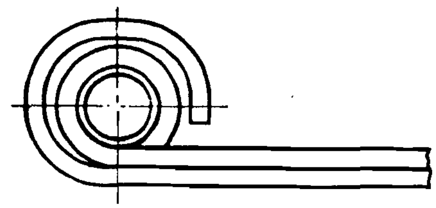


BERLIN EYE

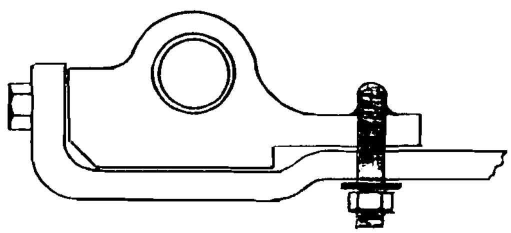


REINFORCED EYE

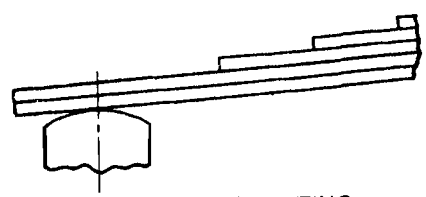
The military or full loose wrappers lengthwise clearance allows relative lengthwise freedom of the main and second leaves. But if the eye of the main leaf should break, the spring is retained in place by the wrapper eye of the second leaf and the vehicle can still be safely driven.



MILITARY WRAPPER



EYE CASTING



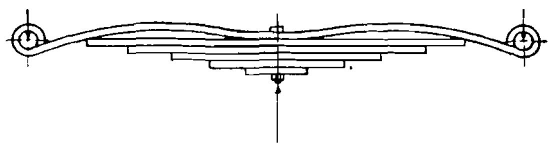
PLAIN END MOUNTING

Heavy-Duty Spring Eyes.

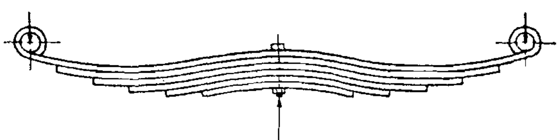
Add a leaf? Adding a leaf, to increase the load-carrying capacity of a spring seems so easy we should think twice before doing so. A properly designed spring is a balanced spring, with leaves so graded or "stepped" in length, with regard to the other leaves, that each leaf carries its fair share of the load. As a result, the strength is in proportion to the stress, throughout the length of the spring.

Realizing the importance of proper leaf stepping, it may be preferable to add two or even three leaves of thinner cross section, in order that the proper form of the spring may be more nearly maintained. If the spring has endured long service and has been repaired more than once, it may be better to have a new spring built that is properly engineered to carry the additional load.

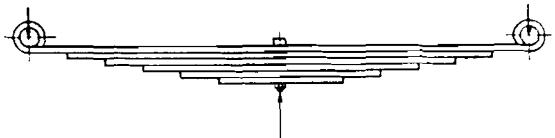
When only one leaf is added, especially on vehicles having the Hotchkiss drive; it is usually the second leaf. The second leaf assists the main leaf in resisting the additional torque and braking strains, due to the overload. Also, the second leaf carries more metal, and more metal does more work. In any case, it is well to consult the spring manufacturers, before making radical changes in the springs.



A—SECOND PLATE TOO SHORT



B—ALL BACKING PLATES TOO LONG

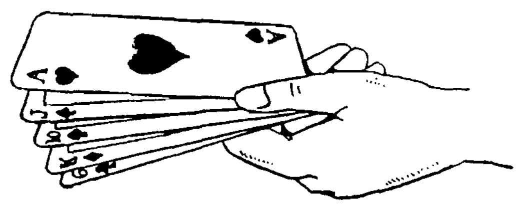


C—S t STEPPING

Correct stepping equalizes stress between all plates.

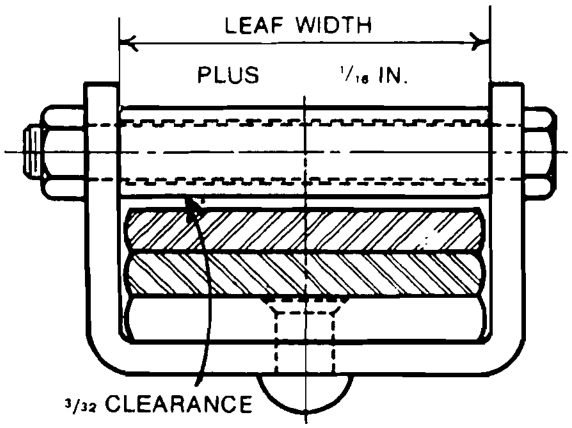
SPRING CLIPS

When a truck wheel hits a bump, the main leaf of the spring is strongly assisted by all the shorter leaves of the spring in resisting the shock. But, after the bump has been passed, the main leaf would ordinarily have to absorb most of the rebound—all by itself—if the main leaf was not assisted in absorbing the rebound by the other leaves, attached to the main leaf by means of rebound clips.



Spring clips prevent break due to fanning.

The secondary function of the rebound clips is to prevent spreading or "fanning out" of the leaves, which might result in eventual breakage. For these two reasons, it is obviously important that broken rebound clips be replaced by "properly adjusted" rebound clips.



Proper Clip Clearances.

While these rebound clips should control the leaves, they should not bind the ends of the leaves against lengthwise motion on each other. The width of the clip, should be 1/16 inch or more over the nominal width of the spring. The spacer tube, over the spring clip bolt, maintains this clearance.

There should also be clearance, between the spacer tube of the clip, and the main leaf of the spring to: (a) allow the "twist" to be distributed over a greater length of the main leaf, when one wheel goes over a bump or drops in a rut, thus placing the axle at an angle. Clips near the ends of the spring should have the greater clearance. (b) Clearance prevents rubbing of spacer tube on and consequent wear and weakening of main leaf, due to notched stick effect.

Clip bolts should be assembled with the head of the bolt away from the tire, so that if a nut should loosen and the clip bolt come partly out, it will not cut the tire.

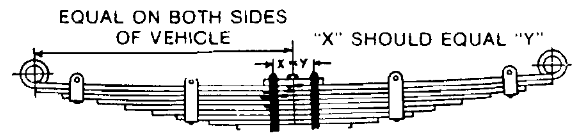
INSPECTION

Because springs usually give such trouble-

free performance, they are apt to be entirely neglected—until trouble actually occurs. However, since springs are both working parts and structural parts, they will well repay the small amount of inspection and preventive maintenance service necessary to keep them in safest operating condition. Such spring inspection may be divided into: (a) Checking the performance of the springs, as shown by vehicle. (b) Checking the springs themselves by actual inspection.

Visual Inspection.

Before a vehicle starts out, experienced mechanics can often spot a sagged coil spring by the low appearance of the front fenders. But a more reliable method is to check the clearance between the chassis frame and the shop floor. Of course the tire inflation must be considered, for greater accuracy. Or the distance between floor and wheel rim can be checked. Any tilting or uneveness of the vehicle body should alert the serviceman to the possibility of sagged springs.



Distance from Fixed Shackle Bolt to Centerbolt should be equal on both sides of vehicle. Distances "x" and "y" should be equal.

On trucks or trailers having helper springs, it is easy to notice the distance between the ends of the helper springs and their pads, when the vehicle is empty. This distance, and the percentage of full load, at which the ends of the helper springs contact their pads varies with different makes and models of vehicles. But on one popular make of trailer, the helper springs contact their pads at 40% of normal full load.

When the vehicle is empty, the distance between the rear end of the helper spring and its pad may be as much as ¼ inch greater than the distance at the front end of the helper spring. That's because, as the vehicle is loaded, the chassis frame pivots around the front axle, so that there is more motion towards the rear.

Now that we know the causes and cures for possible spring troubles, let's make our spring check in this, or some other systematic manner, because, by following the same order each time, we are less apt to miss anything.

1. Check leaves. (a) for displacement out of position, (b) for checks or cracks or actual breakage of individual leaves, (c) for wear, due to rubbing of spring clips on main leaf, (d) for sagging or bent leaves.

2. Center bolt (a) should be equidistant between two U-bolts, (b) should not be bent, loose or broken.

3. Check U-bolt nuts for tightness. Rap with hammer, if necessary to check for thightness. Tighten securely, with wrench handle of adequate length. Check spring seats for wear, if U-bolt nuts have been loose.

4. Check spring clips. (a) for free fit between clips and edges of leaves, (b) should be 1/16 inch clearance between main leaf and clip bolts nearest ends of spring, to allow for twist. Less clearance is needed for clip bolts nearer center of spring.

5. Check spring eyes for (a) opening up

or cracks, (b) for free but not a sloppy fit on spring shackle bolts, (c) for lubrication.

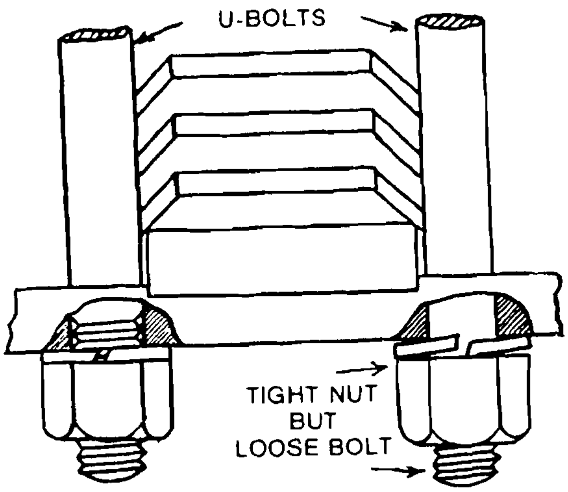
6. Check spring shackle bolts for: (a) wear, (b) tightness.

7. Check radius rods or other related parts of spring suspension, if any.

8. Check shock absorbers, as defective shock absorbers will definitely shorten spring life.

It is important to remember that nearly all leaf spring fractures are of the progressive type—they start small. This gives the inspector a chance to locate small checks and cracks—before they become large fractures. Since steel is stronger in compression than in tension, most fractures start at the outer edge of the tension sides of the leaves.

Building codes give a laminated wood beam a much higher safety rating than a beam of solid wood. The laminations (plates) of a leaf spring also give the leaf spring a higher safety rating—because it is very seldom that more than one leaf breaks at a time. The breakage of one leaf usually gives "warning" by (a) by the feel of the ride, (b) by the position of the vehicle body. This gives ample time to replace it, before other leaves are damaged by the overload.



Nuts may be tight while bolts are loose.

However, let's not overwork this safety factor, but use reasonably careful driving to finish the day's run and then replace the broken leaf—before any other leaves are damaged by the "concentration" of stress over the edge of the broken leaf. However, if the main leaf is broken (unless the second leaf is of the "wrapper" type, or there is a military wrap of the spring eye) it may be preferable to tow the vehicle to the service station. With either the military wrap of the second leaf around the eye of the main leaf, or the wrapper type of second leaf, the vehicle may usually proceed under its own power.

On the road. A tendency to "strike bottom" or hit the rubber bumpers may result from: (a) excessive overload, (b) sagged springs, due to speed too great for load and road.

Springs of modern design are usually nearly flat—under normal full load conditions. When springs are nearly flat, they

are in a better position to endure constant flexing, and they also tend to act as straight radius rods and so maintain axle positions and steering alignments more accurately. Consequently, when such modern springs have "reverse camber," the vehicle may be suspected of: (a) overloading of vehicle, (b) sagged springs. (Springs of earlier designs often had more "arch" or camber and so may not have reverse camber, even when overloaded or sagged.)

Position of shackles should be noted, to see if the angles of these shackles on the two sides of the vehicle are the same. Modern design of spring shackles, places the shackle at an angle which places the main leaf in compression—rather than in tension. This slows down the oscillation rate, or rate of bounce, and so gives a more comfortable ride. The shackle angle, for that particular vehicle, should be used as a guide. Wrong shackle angle may indicate a spring that is too long or too short for that vehicle. Also some present designs are in reverse camber under full load and are not overstressed in this position.

Inspecting springs for quality and workmanship.

1. Center hole. If made with good dies, it will be clean-cut. A poor center hole may set up additional strains in the steel, which may cause premature breakage.

2. Trim points. Must be done with good equipment, to avoid cracking, chipping and rough edges.

3. Clips. Must be right size and shape to fit properly.

4. Eyes. Must be: (a) Tight. (b) Accurate-

ly sized. If eye is too small, bushing may be crushed when forced in. If eye is too large, bushing will be loose. (c) Must be parallel and straight, to avoid setting up excess strains in the main leaf.

5. Fitting of leaves must be accurate, to avoid setting up excess stresses in steel and causing premature breakage.

6. Leaves must be fitted side to side, as well as surface to surface.

7. Proper heat treatment.

DRIVING TIPS

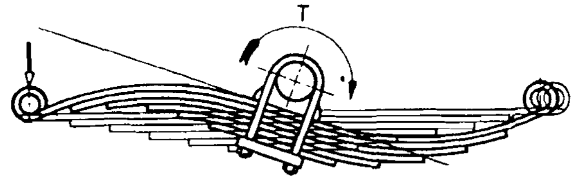
Engineers evaluate the factors determining the life of springs somewhat roughly in this manner.

Design. When vehicles operate under special conditions, special design may considerably reduce spring costs per mile. Vehicle manufacturers produce for average conditions. Under special conditions, redesign may be necessary to secure improved performance.

Steel. Spring companies generally use steel of SAE specification 5160 or 51B60 which are developed for leaf spring use.

Processing. The manufac ure of springs includes the forming and the heat-treating of the steel to temper and toughen it, and is equally as important as the steel itself. Heating and forming of heat treated steel will greatly reduce the strength of the steel by loss of proper heat treating and represents a serious safety hazard.

Maintenance. Like such other vehicle parts as tires, engines, etc., the best made springs may be greatly handicapped by lack of proper maintenance.



Springs Cushion Brake and Torque Reactions.

Vehicle Driver. The driver is the last but very important factor! To appreciate this, let's examine the action of the Hotchkiss drive, which is widely used because of its important advantage in protecting other vehicle parts by providing resilient control of brake and torque applications.

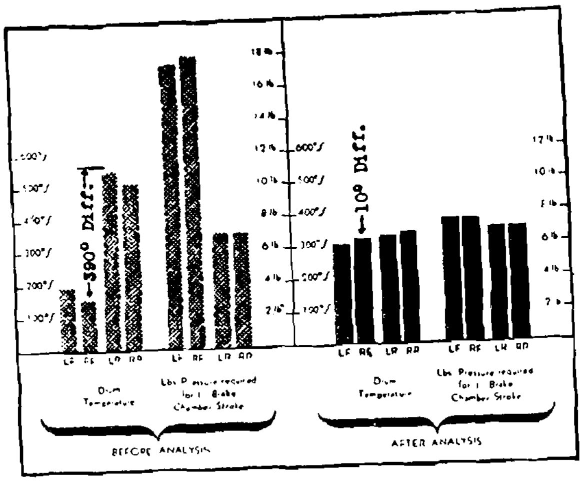
In the Hotchkiss drive, the leaf springs do three things: (a) resiliently support vehicle, to protect driver and load from damage by road shock, (b) resiliently control brake and torque applications, (c) act as structural members to position axle, both lengthwise and crosswise, with regard to chassis frame.

When the brakes are suddenly applied, the entire momentum of the moving vehicle tends to rotate the axle in a forward turning direction. At high speeds, the power of this momentum is terrific (As proven by collisions!) and the effect of this momentum on the axle is limited only by the skidding of the rubber tires on the road. This causes brake "wind-up of springs" which tends to bend springs in "S" form as shown in sketch. Also, when starting a vehicle under adverse conditions of road, load or grade, the driver may race the engine and develop a lot of momentum in the fly-wheel. This torque is greatly multiplied by the transmission and this is again multiplied by the rear axle gears. So it is better (for all parts of the vehicle) not to race the engine and then let the clutch in with a "Bang!"

Suppose the driver has been driving too fast and doesn't see a bump in the road until he is almost on to of it—what should he do?

Of course he should have had the vehicle under better control. But in this predicament, he should apply the brake **before** reaching the bump, and then release brake in sufficient time to allow springs to regain normal position as the wheels (unchecked by brakes) roll freely over the bump.

Otherwise it is possible for the brake reaction to have forced the spring into such a position that one-half of the spring was carrying the full weight of the vehicle, so the effect of the bump would be "twice" as great as when the wheels were allowed to run freely over it.



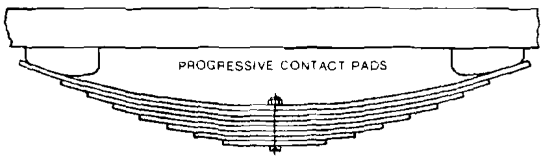
Unfair to Springs! Are Unequalized Brakes.

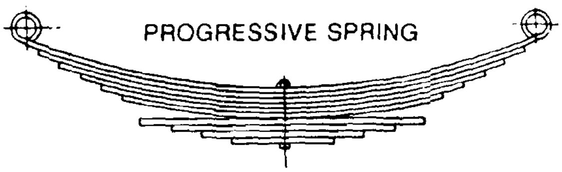
Busses travel over the same routes and with the same variations in load for long periods, and bus operators keep accurate

records of costs per mile. Consequently, fleet operator's experiences are of value as to how low operating spring operating costs may be achieved.

Some bus operators hot stamp the numeral "1" near the center bolt hole to indicate that the spring has been repaired once by the installation of one or more leaves. After the second repair, the numeral "2" is stamped on. The next time repairs to that spring are indicated (after the spring has been repaired twice) a new spring is installed. Under continual flexing, all steel eventually fatigues, although good steel lasts far longer than poor steel. So it is necessary to feed some new metal into a bus fleet occasionally, to secure reliability.

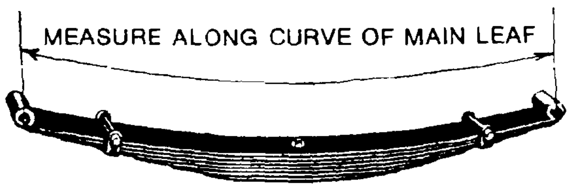
Like the inexpensive fuse which protects a more costly electric motor, the springs, which protect the more costly vehicle, should be regarded as "expendables"—to be replaced, when the limit of their "economic" life has been reached. Batteries, tires, and springs could be designed to last the entire life of the vehicle. But well designed springs, even though they require a minimum of care and occasional replacement, reduce vehicle costs per mile—which is the final yardstick by which satisfactory spring service is measured.





Progressive Springs tend to equalize riding comfort under both light and heavy loads.

Springs of the progressive type not only give almost equal riding comfort for the lightly loaded and fully loaded vehicle, but they also have the additional advantage that there is less **variation** in spring deflection from light load to full load. Consequently the chassis frame remains more nearly level and better steering alignments and greater safety are obtained.



Spring length is measured along curve of main leaf.

Length of springs is measured along the main leaf, from center to center of the two eyes. That's the same distance as center-to-center distance, between the two eyes, when the main leaf is flat under normal full load.